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Simulation of ion-induced nucleation in the CLOUD chamber

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Abstract. A comparison between the binary Sulphuric Acid Water NUCleation model SAWNUC and CLOUD results is presented. Comparison includes direct comparison with a battery of particle counters of various counting efficiencies and APi-TOF charged cluster distribution. A good agreement is found for nucleation rates at various temperatures.

Keywords: Ion Induced Nucleation, CLOUD experiment, nucleation modelling
PACS: 82.70.Rr, 82.60.Nh, 64.60.Q-

INTRODUCTION

The contribution of aerosols to climate is one of the most uncertain factor in global warming [1]. Currently the contribution of nucleation to atmospheric aerosol concentrations is topic of debate. Nucleation could contribute to some extent to the global aerosol population [2]. To understand nucleation is therefore an important part in understanding earth climate. The current understanding of nucleation in the atmosphere suggests a fundamental role of sulphuric acid. Nucleation can be enhanced by ionising radiation and the contribution of stabilising trace vapours [3]. Especially the contribution of Galactic Cosmic Rays (GCR), that are the major source of ions in the atmosphere, on nucleation is currently up for debate [4, 5]. To investigate the influence of ionising radiation, temperature and atmospheric trace gases on particle formation the CLOUD experiment was set up at CERN.

This contribution will present the results of a comparison between the results of binary nucleation experiments in CLOUD and the Sulphuric Acid Water NUCleation model [6]. This model allows to compare the CLOUD results with previous studies on nucleation [7, 8] and ion thermodynamics [9, 10]. Furthermore the model is used to investigate some general aspects of nucleation experiments.

MODELLING

To calculate the influence ionisation on binary sulphuric acid water nucleation the SAWNUC model was created [6]. Evaporation rates in the model are based on measured

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charged cluster thermodynamics for small clusters [9, 10], bigger clusters are treated with classical thermodynamics and evaporation of intermediate charged clusters is based on interpolation. Neutral evaporation rates for the clusters containing two and three H_2SO_4 molecules are based on measurements and classical thermodynamics [11]. The model was adjusted to represent conditions in the CLOUD chamber. These adjustments include counting efficiencies of particle counters [12] and losses to the chamber wall. The particle counter measurements for low temperature binary nucleation events (both neutral and ion induced) are compared with SAWNUC. This comparison allows to investigate how counting efficiencies influence nucleation experiments.

RESULTS

Beside the direct comparison between previous work on binary nucleation and CLOUD, SAWNUC was also used for a variety of further detailed studies. It is important to take the shape of CPC counting efficiencies into account. The shape influence the time at which the first particles occur as well as the peak particle formation rate. This is especially important under conditions with low growth rates. The charged cluster thermodynamics from [6, 9, 10] is compared to measurements done in CLOUD with an APi-TOF measuring negative polarity [13]. By removing cluster evaporation SAWNUC can be used to model situations of kinetically limited nucleation. This allows to investigate effects that occur in these systems, such as depletion of H_2SO_4 and help interpreting the results of nucleation and growth experiments. Furthermore the influence of wall losses on $\frac{d\log(J)}{d\log[H_2SO_4]}$ was investigated. This gives insight how the experimental set up affects interpretation of nucleation experiments.

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